

METHOD AND DEVICE FOR THE GENERATION OF SPECIFIC
ELEMENTS OF AN IMAGE AND METHOD AND DEVICE FOR THE
GENERATION OF OVERALL IMAGES COMPRISING SAID SPECIFIC
ELEMENTS

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The invention relates to a method and a device for
generating specific elements having characteristics
different from those of the majority of the generic
elements of an image, in particular of calligraphic
10 light points having a resolution, a positional accuracy
and a contrast greater than the rest of the image. It
also relates to a method and a device for generating
overall images using the method of generating specific
elements, and a flight simulator using this device, in
15 particular aircraft simulators that can be certified at
the highest level of qualification by the official
bodies.

In a visual airplane or helicopter simulator system,
20 the representation of the runway lights must be
extremely accurate and realistic in order to satisfy
the pilot training requirements, as defined by the
current regulations (level D of the circulars FAA
AC120-40B and JAR STD 1A). The resolution of these
25 lights, their positional accuracy and their contrast
relative to the rest of the scene outstrip the
capability of the current "raster" mode controlled
projectors (television type scanning).

30 This display is therefore produced by dedicated
projectors sequentially displaying the visual scene
made up, for example, of polygons (runways, buildings,
ground, etc.), in a so-called TV mode, then finally,
the runway lights with a particular so-called
35 calligraphic mode in which the spot can be positioned
in the x-y frame of reference anywhere in the image and
remain there for the time required to obtain the

required brightness. This mode provides for both extremely bright lights and lights positioned with a very high accuracy. Such lights are called calligraphic light points or even light points.

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These days, for such flight simulator applications, dedicated image generation machines are used, that are complex and costly (more than 100 000 € per visual channel). Reducing the costs and the complexity of the overall image generation devices for such applications including calligraphic light points could be envisaged by using the latest consumer graphics cards. In practice, these consumer graphics cards offer a performance level and image quality that would satisfy FAA/JAA certification requirements. However, these consumer graphics cards cannot be used to generate calligraphic light points.

In the current architecture of an overall image generator, the pixel processor computes the brightness of the calligraphic light points after having computed the brightness of the pixels of the 2D image. The brightness information of each of the lights is then linked to its 2D coordinates for display on the projector in calligraphic mode. This method is made possible because the depth information relative to the observation position is directly available on the card (Z-buffer, range buffer or equivalent type algorithm).

Therefore, in the current overall image generation devices, the problem of managing the calligraphic light points and, in particular, their possible masking by other elements in the scene, has been introduced at design level. Such an integration at the design stage in the consumer graphics cards cannot be envisaged.

In a market-standard graphics card for PCs, the geometric processor and the pixel processor are integrated on the graphics processor of the card. It is

normally not possible, without the support of the card manufacturer, even of the graphics processor manufacturer, to access the depth information with which to manage masking situations.

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This introduces a dependency with regard to manufacturers. Now, the manufacturers of this type of card are not interested in the simulation market, in particular at the higher level of the FAA/JAA
10 standards. This lack of interest is linked to the fact that it is too narrow a technological niche, representing a market of only a hundred or so channels per year.

15 Furthermore, the current solution is specific to the graphics processor used and is not, therefore, immediately portable. The use of a new card equipped with a different graphics processor then requires a modification of the calligraphic light point
20 computation.

The present invention seeks to overcome these drawbacks by separating the method of generating generic elements, in particular elements of the observation
25 scene, from the method of generating specific elements, in particular calligraphic light points, so making it possible to use consumer graphics cards for the generation of the generic elements and for the separate implementation of these two generic element and
30 specific element methods on conventional computers, such as PCs.

One subject of the invention is a method of generating specific elements having characteristics different from
35 those of the majority of the generic elements of an image such that the generation of these specific elements is performed independently of the generation of the generic elements of the image.

In addition, the method of generating specific elements according to the invention can include the determination of the impact of these generic elements on the specific elements.

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Furthermore, the determination of the impact on the specific elements can include, for each specific element:

- 10 - the classification of the generic elements as generic elements to be tested if these generic elements are contained by a subdivision of the vision pyramid defined by the observation point including the specific element,
- 15 - the determination of the generic elements having an impact on at least one specific element by scanning through all the generic elements to be tested in order to determine if one of these generic elements is intersected by the straight line passing through the observation point and the specific element,
- 20 - the computation of the impact on the specific element from the generic element determined as having an impact,
- the classification of the generic elements can be used to reduce the required computing power.

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The invention also proposes a device for generating specific elements implementing the method of generating specific elements above, including means of determining the impact of the generic elements on the specific elements.

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Another subject of the invention is a method of generating overall images including specific elements having characteristics different from those of the majority of the generic elements of the images, characterized in that it includes:

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- on a first channel:
 - extraction of the N-dimensional coordinates (N being an integer greater than or equal to 3) of the

generic elements, from the observation point provided and a visual database,

- the computation of the 2D image according to the generic coordinates extracted;
- 5 - on a second channel, the method of generating specific elements described above.

The invention further relates to a device for generating overall images including:

- 10 - on a first channel, means of generating generic elements implementing the extraction of the generic elements and the computation of the 2D image of the above method of generating overall images;
- on a second channel, means of generating specific
- 15 elements implementing the method of generating specific elements described above.

The invention can be used by a flight simulator which therefore includes the above device for generating

20 overall images.

The characteristics and advantages of the invention will become more clearly apparent from reading the description, given as an example, and the related

25 figures which represent:

- figure 1, an example of current architecture of the method of generating overall images with calligraphic light points according to the state of the art,
- figure 2, an example of architecture of the method of
- 30 generating overall images with specific elements according to the invention,
- figure 3, the principle of the so-called "ray tracing" method implemented by the method of determining impact of generic elements on specific
- 35 elements,
- figures 4a and 4b, the principle of classification of the generic elements by subdivision of the vision pyramid according to the invention: figure 4a showing a pyramid before subdivision and figure 4b after a

first subdivision.

The aim of the method according to the invention is to generate specific elements F of overall images. To
5 reproduce these specific elements F , the projector is interfaced via a dedicated graphics card in order to control the projector in this specific mode. The specific elements F of an overall image are differentiated from the generic elements E_G of the image
10 in that they have different reproduction characteristics from the generic elements E_G . These different characteristics are, for example, that the resolution, and/or the accuracy, and/or the contrast of these specific elements F are greater than those of the
15 generic elements E_G .

In the following examples, the generic elements E_G of the image will be made up of polygons and the specific elements F of calligraphic light points. The specific
20 mode will, then, be the calligraphic mode and the generic mode will be the TV mode. These examples can be transposed to any type of generic elements E_G : dots, segments, polyhedra, etc., and to any type of specific elements.

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In the current architecture represented by figure 1, the method of generating overall images is implemented by a complex image generator.

30 This complex image generator has two channels:

- the first channel for the TV mode providing the control instructions $C_s(t)$ for the graphics card interfacing the projector to reproduce the observation scene,
- 35 - the second channel for the calligraphic mode providing the control instructions $C_F(t)$ for the specific graphics card interfacing the projector to reproduce the calligraphic light points F .

From the observation position $P_o(t)$, the 3D coordinates of the visual scene (of the generic elements) E_g are extracted by extraction means 11 from a visual database B. Initially, the 2D geometry of the image corresponding to the scene and of the calligraphic light points in the observation window defined by the observation point $P_o(t)$ is computed, for example, by a geometric processor 12. Secondly, the masking and the brightness of the calligraphic light points $L_f(t)$, are computed after having computed the brightness of the pixels of the 2D image $C_s(t)$, for example, by the pixel processor 13. The brightness of the pixels of the 2D image $C_s(t)$ is transmitted to a graphics card (not shown) to control the projector (not shown) in TV mode.

Again from the observation position $P_o(t)$, the 3D coordinates of the calligraphic light points (of the specific elements) F are extracted from the visual database B by light extraction means 21. Firstly, the 3D coordinates of the calligraphic light points F in the observation window defined by the observation point $P_o(t)$ are converted into 2D coordinates by conversion means 22. Secondly, the brightness information of each of the lights $L_f(t)$ computed by the first channel is then linked by association means 24 to its 2D coordinates determined by the second channel for display on the projector in calligraphic mode. This method is made possible because the depth information relative to the observation point is directly available on the card (Z-buffer, range buffer or equivalent type algorithm).

In order to reduce the costs and complexity of the generators of overall images with specific elements, such as, in particular, calligraphic light points, the invention proposes a new architecture of the method of generating such images and, in particular, of generating specific elements, which has the advantage of making the generation of the specific elements

independent of the generation of the generic elements. Thus, by separating the generation of specific elements 20 from the generation of generic elements 10, the use of consumer graphics cards and computers is made possible.

The new architecture proposed in figure 2 therefore allows for the completely independent computation of the TV image and the calligraphic light points. The main advantage of this solution is that it makes it possible to follow the continually improving performance levels of the graphics processors by using the most powerful graphics card of the time without modifying the computation of the calligraphic light points.

The method of generating specific elements that is the subject of the invention is illustrated by the second channel of figure 2.

Extraction means 21' extract from the visual database B, from the observation position $P_o(t)$, the 3D coordinates not only of the specific elements F, the calligraphic light points in our example, as in the prior art, but also of the generic elements E_g , the polygons forming the scene in our example. The 3D coordinates extracted from the specific elements F are converted into 2D by conversion means 22, and the impact of the generic elements on the specific elements, the brightness of the calligraphic light points according to the masking in our example, $L_f(t)$, is determined by impact determination means 23. The association means 24 receive the 2D coordinates of the lights from the conversion means 22 and the brightness information for each of the lights $L_f(t)$ computed by the impact determination means 23.

To implement such a method of generating specific elements, the second channel or calligraphic channel

can include one or more PC or equivalent computers,
synchronized with the preceding one, having a copy of
the database B and computing the masking situations by
a method of determining the impact of the generic
5 elements on the specific elements implemented 23 for
example, in a purely software form. This method of
determining the impact of the generic elements on the
specific elements 23 is described in greater detail
below.

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A card in PCI or equivalent format provides the
interface with the calligraphic input of the projector.
It is also used to generate special atmospheric effects
by defocusing the lights. This card is simple and
15 inexpensive, it can be set up by programming an FPGA
according to the projector used.

The method of generating overall images including
specific elements proposed by the invention therefore
20 includes, on a first channel or graphics TV channel, a
method of generating generic elements 10 including:

- the extraction 11 of the N-dimensional coordinates (N
being an integer greater than or equal to 3) of the
generic elements E_G , from the observation point
25 provided $P_o(t)$ and a visual database B,
- the computation 12' of the 2D image according to the
generic coordinates E_G extracted.

This graphics TV channel can include a PC or equivalent
30 with unmodified market-standard graphics card.

This new architecture makes it possible to use one or
more machines according to the required performance
levels and the commercially available technologies, and
35 it therefore presents a very high level of scaling
flexibility. A visual system that does not have the
calligraphic function can now easily be modernized
using this solution, and without compromising the
existing architecture.

Thus, the device for generating overall images including means (10) of generating generic elements (E_G) and means (20) of generating specific elements (F) can include:

- either a single first processor (not shown) including both means (20) of generating specific elements (F) that can be interfaced with at least one projector via an electronics card and means (10) of generating generic elements (E_G),
- or a first processor including means (20) of generating specific elements (F) that can be interfaced with at least one projector via an electronics card, and a second processor including means (10) of generating generic elements (E_G).

Said first processor possibly including the generic mode graphics card.

Furthermore, the flexibility of the solution for separating the two channels illustrated by figure 2 makes it possible to produce special effects based on the use of the calligraphic light points, such as the reflection of the lights on a wet runway in a very realistic way, whereas this is virtually impossible with a conventional solution.

The invention also relies on the determination of the impact of the generic elements on the specific elements, for example, by a masking algorithm that is very powerful in terms of computing power, that can be run on a PC type conventional computer.

The computation of the masking, relative to an observer, of a point belonging to a visual scene is very costly in terms of computing power required with a conventional solution and requires a dedicated computer card, coupled with the rest of the image generator.

The method of determining impact, in particular masking, described above, considerably reduces the computing power required through its design suited to the problem posed, that is, the masking of light
5 points. The training requirements set at around 5000 the number of lights to be computed per graphics channel within an allotted computation time of less than 25 ms.

10 The method used to determine whether the generic elements have an impact on the specific elements (in particular, whether the calligraphic light points are seen or masked) is based on the "ray tracing" method.

15 The determination of the generic elements (E_G) having an impact on at least one specific element is performed by scanning all the generic elements (E_G) to be tested in order to determine whether one of these generic elements (E_G) is intersected by the straight line
20 passing through the observation point and the specific element.

In our example, the image is made up of generic elements E_G comprising polygons and of specific elements
25 (lights) represented by stars. The ray tracing principle presented by figure 3 consists in defining, for each light, the straight line passing through the observation point $P_0(t)$ and this light $F_k (1 \leq k \leq K)$, and in scanning all the polygons of the image to
30 determine whether one of them is intersected by the straight line (and therefore masks the light concerned). However, given the very high number of polygons and of lights present in the images processed routinely, the ray tracing method described above would
35 inevitably lead to an exponential number of computations making this method expensive in terms of computation cost.

In order to reduce the computing cost of the impact

determination method, the ray tracing principle can be retained while also implementing a classification of the rays with which to vastly reduce the number of intersections computed.

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This classification of the generic elements (E_G) makes it possible to discard as generic elements (E_G) to be tested the generic elements (E_G) contained by a subdivision of the vision pyramid defined by the observation point including the specific element as illustrated by figures 4a and 4b.

Thus, the impact determination method using the classification makes it possible to avoid an exhaustive processing of the straight line/polygon intersections, that is very costly, by constructing on each cycle a classification of these elements according to their position relative to the observer. This classification is made by subdividing the vision pyramid, which in many cases means that certain polygons, that are known not to be able to mask any lights, no longer need to be tested.

In the example illustrated by figures 4a and 4b, the subdivision of the vision pyramid Y_v of the figure 4a leads to two sub-pyramids Y_{s1} and Y_{s2} of figure 4b. In the case illustrated by figure 4b, the classification makes it possible to note that one of the sub-pyramids Y_{s2} contains no light F_k (the lights being represented by stars), and that it is therefore pointless to take account of all the polygons E_G (represented by straight line segments) that it contains.

This subdivision principle, applied with a number of iterations, can be used to obtain a partition of the vision pyramid Y_v in tree form and, ultimately, to considerably reduce the number of straight line/polygon intersections computed.

Having thus determined, more quickly thanks to the classification, the generic element E_G having an impact on a given specific element F_k , the impact is computed (for example, the resultant brightness in the case of a total or partial masking, the defocusing in the case of atmospheric effects, the optical reflection in the case of a reflection on a generic element such as, in particular, a wet surface, etc).

- 10 The novelty of the impact determination method with classification relies on four factors:
- The data structure is thus optimized.
 - The classification of the traced rays considerably reduces the number of intersections computed.
 - 15 - Some of the processes can be performed asynchronously, because the results do not vary rapidly. They correspond to a first reduction of the list of elements that can have an impact on the calligraphic light points.
 - 20 - The computation of the impact proper is performed synchronously.

Thus, the classification and the determination of the generic elements (E_G) having an impact can be carried out asynchronously, and the computation of the impact can be carried out synchronously.

The present impact determination method with classification can be used to process all operational operating cases, including, in particular, cases of masking by moving objects in the scene (vehicles on the ground or air traffic) or by semi-transparent or textured faces, such as cloud layers, for example.

35 The present impact determination method with classification can be used to divide by approximately 10 the computing power needed compared to the conventional algorithms used today.

The device , for generating overall images with calligraphic light points enables the calligraphic light points to be processed by a purely software solution running on market-standard hardware, using a
5 ray tracing algorithm to compute the masking of the calligraphic light points, with:

- An optimized data structure and a classification of the traced rays to reduce the number of intersections computed.
- 10 - Some of the masking computations performed asynchronously and the computation of the masking proper performed synchronously.

Flight simulators equipped with such a device for
15 generating overall images implementing the specific element generation method of the invention satisfy current regulations. In particular, the impact determination method with classification satisfies certain masking and reflection-related requirements in
20 these regulations.

The present invention therefore relates to a new architecture comprising two separate channels corresponding, respectively, to the generic and
25 specific modes, enabling the use of consumer graphics cards and the implementation of light masking computations on PC type market-standard computers, so saving on development and on the purchase of dedicated graphics cards that are still very expensive.